Annals of Clinical and Analytical Medicine
Original Research

Comparison of two different surgical treatments of forearm double diaphysis fractures in adolescents

Adolescent period forearm double bone diaphysis fractures

Duran Topak[1], Fatih Doğar[1], Muhammet Yıldız[1], Ökkeş Bilal[1], Özhan Şakı[2], Ersin Ekici[2]
[1] Department of Orthopaedic and Traumatology, Kahramanmaras Sutcu Imam University Faculty of Medicine
[2]Department of Orthopaedic and Traumatology, Kahramanmaras Necip Fazıl City Hospital, Kahramanmaras, Turkey

Abstract

Aim: In this study, it was aimed to compare the clinical and radiological results of the two different surgical methods for the treatment of forearm double bone diaphysis fractures in children at early and mid-adolescence (ages 10–16).

Materials and Methods: Children aged between 10 and 16 years who underwent surgical treatment for a forearm double bone fracture between the years 2015–2019 were evaluated retrospectively after the approval of the local ethics committee. The patients were separated into two groups: TEN group included 34 patients for whom both bones were fixated with TEN following closed reduction; plate-screw osteosynthesis (PO) group included 18 patients who had fixation with PO following open reduction.

Results: A total of 52 children with forearm double bone diaphysis fracture with the mean age of 12.40±1.79 (10–16) years, 86.5% (n=45) of whom were males and 53.8% (n=28) had left side fracture were followed up for 30.40±14.03 (12–64) months. When the data of both groups were compared, it was observed that average union time was shorter compared with the PO group and the difference was statistically significant (p=0.007). When the functional results and complication rates of the two groups were compared, there was no statistically significant difference found between the two groups (p=0.756 and p=0.052, respectively).

When the number of radiographs of both groups was compared, it was observed that the number of radiographs during the operation, during implant extraction, and total radiography was higher in the TEN group compared with the PO group and that the difference was statistically significant (p=0.000, p=0.002, p=0.000, respectively).

Discussion: TEN after closed reduction can be safely preferred for pre-adolescent period children with adequate remodeling capacity and incomplete skeletal maturity because of its positive outcomes including less operation and hospital stay duration, fast union, better cosmetic results. However, plate-screw following open reduction can be preferred for mid-adolescent period children with complete or near-complete skeletal maturity and limited remodeling capacity because of its positive aspects such as rigid fixation, anatomic reduction, and less radiation exposure.

Keywords

Adolescent; Forearm double; Diaphysis fractures

DOI: 10.4328/ACAM.20253 Received: 2020-06-18 Accepted: 2020-06-29 Published Online: 2020-07-04 Printed: 2020-09-01 Ann Clin Anal Med 2020;11(5):457-461
Corresponding Author: Duran Topak, Department of Orthopaedic and Traumatology, Kahramanmaras Sutcu Imam University Faculty of Medicine, Kahramanmaras, Turkey.
E-mail: drdtopak@gmail.com P: +90 344 300 3331 F: +90 344 300 4045
Corresponding Author ORCID ID: https://orcid.org/0000-0002-1442-3392

Introduction

Double bone fractures of the forearm constitute 5.4% of all fractures and 30% of upper limb fractures in pediatrics [1, 2]. They are the 2nd most common type of fractures in the adolescent age group [3]. The incidence rate of forearm double bone fractures among children has been increasing in recent years [2].

Approximately 85% of pediatric forearm double bone fractures are treated perfectly by conservative methods, but some children may develop limitations in forearm rotation [4, 5]. However, surgical treatment is needed for patients with fragmented, unstable, irreducible fractures or fractures with an unacceptable angling after reduction, open fractures, and fractures along with soft tissue damage [6-9]. In recent years, despite the lack of evidence guiding optimal surgical methods, there is a tendency toward surgical treatment in pediatric and adolescent forearm double bone fractures [10].

However, the ideal method of fixation in children aged 10–16 years with a double fracture of the forearm is still controversial [2]. Elastic intramedullary nailing technique was first described in the late 1970s and has been successfully applied with little change since then to the present day [10]. TEN is considered to be the ideal treatment for children with incomplete skeletal development due to its many positive aspects, such as less damage to the soft tissue, short operation duration, and fast union duration [11-13]. Perfect results are achieved in pediatric forearm double bone fractures by providing rigid internal fixation after anatomical reduction with plate-screw osteosynthesis (PO) after traditional open reduction [14].

The objective of this study was to compare the clinical and radiological outcomes of treatment of forearm double bone diaphysis fractures via two different types of surgical techniques among early and mid-adolescence children aged 10–16 years.

Material and Methods

Children aged 10-16 years who underwent surgical treatment for a double bone forearm fractures between the years 2015–2019 at our clinic were evaluated retrospectively after the approval of the local ethics committee (Session: 2020/07, Date: April 15, 2020, Decision no: 11).

Patients aged 10–16 years who had surgical treatment performed due to forearm double bone fracture, who had type 1 open fracture, fractures that were 5 cm or farther from both joints (wrist and elbow), for whom both fractures were fixed with TEN or plate-screw, who had arterial injury without nerve injury, who had a primary repair performed, and who had at least 12 months of the follow-up period were included in the study. Fracture of the upper extremities on the same side, open fractures of type 2 or type 3, compartments opened due to fasciotomy, pathological fractures, nerve injuries, concomitant vital organ injury, complex special fractures (such as Galeazzi and Monteggia fractures), fractures closer than 5 cm to the joint, fractures in which radius and ulna were each fixed with different implants were excluded from the study.

Fifty-two patients meeting the criteria were included in the study and their files were examined retrospectively. Patients were separated into two groups as follows: TEN group with 34 patients in whom both bones were fixed with TEN after closed reduction; PO group with 18 patients in whom the bones were fixed with PO after closed reduction.

Later, age, gender, direction, fracture etiology, surgery indication, operation indication, operation durations, number of radioscopy scans (fracture operation, implant extraction operation, and total operation), time of implant removal, complications, hospitalization durations, and follow-up durations were evaluated from the patient files. Union time and angling amount on the fracture line were recorded from the radiographic examinations of the patients. In the final follow-up of the patients, functional and cosmetic evaluations were carried out according to the criteria defined by Price et al. [15]. To determine the time of union, anteroposterior and side radiographs were used, three cortex continuity and absence of pain in the fracture line were evaluated as a union (Figures 1, 2). The determination of the number of radiographs was determined as the total number (per unit) of imaging during the operation.

Statistical Analysis

IBM SPSS 20.0 (IBM, Armonk, NY, USA) package program was used to analyze the data obtained from patient files. Categorical variables were defined as frequency (n, %), whereas quantitative data were defined as (mean±SD). The Kolmogorov–Smirnov and the Shapiro–Wilk tests showed that the two groups did not match the normal distribution. The chi-squared (x2) test was used in the comparison of the categorical variables of two independent groups and the Mann–Whitney U test from non-parametric tests was used to evaluate the quantitative data. $P<0.05$ was considered statistically significant.

Results

A total of 52 children with forearm double bone diaphysis fracture with the mean age of 12.40±1.79 (10–16) years, 86.5% (n=45) of whom were males and 53.8% (n=28) had left side fracture, were followed up for 30.40±14.03 (12–64) months. When the etiological factors of the cases were evaluated, it was observed that the fractures occurred most commonly as a result of falling in the house (n=15), sports injuries (n=15), and playgrounds accidents (n=15). Most common surgery indications were irreducible fracture (n=15), loss of reduction (n=15), and unacceptable post-reduction position (n=14), respectively. The demographic data of the cases by groups are shown in Table 1. When the data of both groups were compared, it was observed that the average union time was shorter compared to the PO group, and the difference was statistically significant (TEN: 8.14±2.74, PO: 11.22±4.41, p=0.007). When the functional results and complication rates of the two groups were compared, no statistically significant difference was observed between the groups (p=0.756 and p=0.052, respectively). The duration of hospital stay in the TEN group was shorter compared with the other group (p=0.000).

Fracture reduction, implant extraction, and total operation durations were shorter in the TEN group and the difference was found to be statistically significant (p=0.000, p=0.000, and p=0.000, respectively). When the number of radiographs of both groups was compared, it was observed that the number during the operation, during implant extraction and total radiography images was higher in the TEN group compared with the PO

group and that the difference was statistically significant (p=0.000, p=0.002, and p=0.000, respectively). A comparison of groups is shown in Table 2.

Table 1. Distribution of demographic data by groups

		Group 1 (n=34)	Group 2 (n=18)
Age (year)		11,73±1,60 (10-15)	13,66±1,45 (12-16)
Gender	Girl	6	1
	Boy	28	17
Side	Right	18	6
	Left	16	12
Etiology	In-Home Fall	12	3
	Sports Injuries	8	7
	Falling down the stairs	1	0
	Playground Accidents	10	5
	Motor Vehicle Injury	3	3
Surgical Indication	Non-Reducible Fracture	11	4
	Unacceptable Position After Reduction	8	6
	Loss of Position	12	3
	Refracture	2	3
	Vascular-Nerve Injury	0	1
	Multi trauma	1	1
Functional Outcome	Exellent	26	14
	Good	6	4
	Moderate	1	0
	Poor	1	0
Complications	Surgical Area Infection	0	1
	Refracture	2	0
	Pin Entry Irritation	5	0
	Hypertrophic Scar	0	2
Implant Removal Time (mounth)		9,08±0,66 (2-36)	16,94±7,20 (8-36)
Following Time (mounth)		30,85±13,91 (12-52)	29,55±14,62 (12-64)

Table 2. Comparison Outcomes of Groups

	Group 1 (n=34)	Group 2 (n=18)	p-value
Age (year)	11,73±1,60 (10-15)	13,66±1,45 (12-16)	0.000
Union Time (week)	8,14±2,74 (4-13)	11,22±4,41 (6-22)	0.007
Operating Time_fracture (min)	34,32±9,10 (20-50)	66,94±14,84 (45-95)	0.000
Operating Time_implant (min)	22,94±9,70 (10-50)	48,72±20,14 (25-125)	0.000
Operating Time_total (min)	57,26±13,11 (35-85)	115,66±23,02 (85-180)	0.000
Fluoroscopy Time_fracture	23,88±7,08 (12-47)	7,27±3,49 (2-14)	0.000
Fluoroscopy Time_implant	3,38±2,76 (0-12)	2,00±4,14 (0-18)	0.002
Fluoroscopy Time_total	27,26±7,67 (12-49)	9,22±6,03 (2-29)	0.000
Length of Hospitalization (day)	1,52±0,66 (1-3)	2,50±1,04 (1-5)	0.000
Functional Outcome (satisfactory result)	32	18	0.756
Complications	7	3	0.052
Mean Follow-up Time (month)	30,85±13,91 (12-52)	29,55±14,62 (12-64)	0.506

Figure 1. Postoperative anterior-posterior and lateral radiograph of the patients who underwent Titanium Elastic Nail due to the forearm double fracture

Figure 2. Postoperative anterior-posterior and lateral radiograph of the patient who underwent Plate-Screw Osteosynthesis due to the forearm double fracture

Discussion

The aim of this study was to compare the treatment results of 10–16 years old patients who had PO performed after TEN and open reduction in forearm diaphyseal double bone fractures. When the functional outcomes and complication rates were compared, it could be observed that both treatment options can be successfully performed in this age group. But the preferred method depends on the experience and preference of the surgeon because of the lack of scientific evidence.

Surgeons often prefer fixation with titanium elastic nails after closed reduction for young children with incomplete skeletal maturity and adequate remodeling capacity, whereas they prefer PO after open reduction for older children with complete or almost complete skeletal maturity and decreased remodeling capacity. This is the cause of the age difference between the two groups in our study.

TEN is defined as a simple and easy-to-apply technique that does not disrupt fracture biology as it is applied with mini

lacerations, without periosteal stripping, by causing less soft tissue damage and frequently applied closed. Therefore, better cosmetic results, rapid union, short operation time, fewer complications, and shorter hospitalization duration are its main advantages [6, 7, 9, 10, 15]. In our study, hospital stay duration was found to be significantly shorter in the TEN group. This may be because when it is applied without the need for soft tissue dissection, post-op pain management becomes easy.

PO after open reduction is a surgical technique that allows early and unprotected movement, as it provides rigid fixation after anatomical reduction. As it is performed with larger incisions and by periosteal stripping, it forms longer incision scars and more soft tissue damage. In addition to the good functional result, long operation duration has been reported [4, 11, 14, 16]. As most of the comparative studies include all pediatric ages, a clear evaluation is not possible. However, a few studies compare children aged 10 years and older.

When TEN application and PO due to forearm double fractures were compared among children in the 10–16 age group, it was reported that although the surgical techniques and fixation options are different, functional results and complication rates are similar [16-21]. In our study, functional results in both groups were similar, and although the complications observed were different, complication rates were the same.

In children aged 10–16 years with double bone forearm fractures, the union time in the TEN group was observed to be longer than in the children undergoing open reduction [21, 22]. However, most studies reported that there was no difference between the two groups in terms of union times [19, 23, 24]. In our study, union time was found to be shorter in the group in which TEN was applied. This could be due to the fact that all patients who were applied TEN also had intramedullary fixation following closed reduction or that they had a lower average age.

In comparative studies, it was noted that the duration of the operation was significantly shorter in the TEN group [19-24]. In patients who were performed TEN, fracture reduction, implant removal and total operation times were found to be significantly shorter compared with the PO group. This is because of the ease of application of the implant.

In their comparative study, Zheng et al. reported that the number of radiography scans in the TEN group was higher than in the PO group [21]. In this study, it can be observed that the number of fracture reduction, implant extraction, and total radiography scans was higher in the TEN group. A large number of radiography scans were the result of insisting on closed reduction and the need for radiography because of the nature of the surgical technique.

In our study, the difference in the average age of the two groups and the retrospective planning of our study were considered the most important limitations. The surgery and the follow-up of the patients conducted by three different surgeons can affect the outcome.

Conclusion

In conclusion, there is no complete consensus among surgeons for the surgical treatment of double bone diaphyseal forearm fractures in adolescence. The applied technique depends on the experience of the surgeon because of the lack of scientific evidence.

TEN after closed reduction can be safely preferred for pre-adolescent children with adequate remodeling capacity and incomplete skeletal maturity because of its positive outcomes such as less operation and hospital stay duration, fast union, and better cosmetic results. However, plate-screw following open reduction can be preferred for mid-adolescent children with complete or near-complete skeletal maturity and limited remodeling capacity because of its positive aspects such as rigid fixation, anatomic reduction, and less radiation exposure.

It should be noted that there is a need for randomized prospective studies with a sufficiently large scale to allow the separate comparison of pre-adolescent and mid-adolescent age groups for definitive results.

Scientific Responsibility Statement

The authors declare that they are responsible for the article's scientific content including study design, data collection, analysis and interpretation, writing, some of the main line, or all of the preparation and scientific review of the contents and approval of the final version of the article.

Animal and human rights statement

All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. No animal or human studies were carried out by the authors for this article.

Funding: *None*

Conflict of interest

None of the authors received any type of financial support that could be considered potential conflict of interest regarding the manuscript or its submission.

References

1. Rennie L, Court-Brown CM, Mok JY, Beattie TF. The epidemiology of fracture in children. Injury. 2007;38(8):913-22.

2. Sinikumpu JJ, Lautamo A, Pokka T, Serlo W. The increasing incidence of paediatric diaphyseal both-bone forearm fractures and their internal fixation during the last decade. Injury. 2012;43(3):362-6.

3. Cheng JC, Ng BK, Ying SY, Lam PK. A 10-year study of the changes in the pattern and treatment of 6,493 fractures. J Pediatr Orthop. 1999;19(3):344-50.

4. Cai L, Wang J, Du S, Zhu S, Wang T, Lu D, et al. Comparison of hybrid fixation to dual plating for both-bone forearm fractures in older children. Am J Ther. 2016;23(6):e1391-6.

5. Price CT, Scott DS, Kurzner ME, Flynn JC. Malunited forearm fractures in children. J Pediatr Orthop. 1990;10(6):705-12.

6. Garg NK, Ballal MS, Malek IA, Webster RA, Bruce CE. Use of elastic stable intramedullary nailing for treating unstable forearm fractures in children. J Trauma. 2008; 65(1):109-15.

7. Sun YQ, Penna J, Haralabatos SS, Carrion WV. Intramedullary fixation of pediatric forearm diaphyseal fractures. Am J Orthop. 2001; 30(1):67-70.

8. Cullen MC, Roy DR, Giza E, Crawford AH. Complications of intramedullary fixation of pediatric forearm fractures. J Pediatr Orthop. 1998;18(1):14-21.

9. Kelly BA, Shore BJ, Bae DS, Hedequist DJ, Glotzbecker MP. Pediatric forearm fractures with in situ intramedullary implants. J Child Orthop. 2016;10(4):321-7.

10. Parikh SN, Jain VV, Denning J, Tamai J, Mehlman CT, McCarthy JJ, et al. Complications of elastic stable intramedullary nailing in pediatric fracture management: AAOS Exhibit Selection. J Bone Joint Surg Am. 2012;94(24):e184.

11. Flynn JM, Jones KJ, Garner MR, Goebel J. Eleven years' experience in the operative management of pediatric forearm fractures. J Pediatr Orthop. 2010;30(4):313-19.

12. Altay M, Aktekin CN, Ozkurt B, Birinci B, Ozturk AM, Tabak AY. Intramedullary wire fixation for unstable forearm fractures in children. Injury. 2006;37:966-73.

13. Kang SN, Mangwani J, Ramachandran M, Paterson JM, Barry M. Elastic intramedullary nailing of paediatric fractures of the forearm: a decade of experience in a teaching hospital in the United Kingdom. J Bone Joint Surg Br. 2011;93(2):262-5.

14. Ortega R, Loder RT, Louis DS. Open reduction and internal fixation of forearm fractures in children. J Pediatr Orthop. 1996;16(5):651-4.

15. Baldwin K, Morrison MJ III, Tomlinson LA, Ramirez R, Flynn JM. Both bone forearm fractures in children and adolescents, which fixation strategy is superior - plates or nails? A systematic review and meta-analysis of observational studies. J Orthop Trauma. 2014;28(1):e8-14.

16. Lee Pace J. Pediatric and adolescent forearm fractures: Current controversies and treatment recommendations. J Am Acad Orthop Surg. 2016;24(11):780-8.

17. Smith VA, Goodman HJ, Strongwater AS, Smith B. Treatment of pediatric

both-bone forearm fractures-a comparison of operative techniques. J Pediatr Orthop. 2005;25(3):309-13.
18. Van der Reis WL, Otsuka NY, Moroz P, Mah J. Intramedullary nailing versus plate fixation for unstable forearm fractures in children. J Pediatr Orthop. 1998;18(1):9-13.
19. Reinhardt KR, Feldman DS, Green DW, Sala DA, Widmann RF, Scher DM. Comparison of intramedullary nailing to plating for both-bone forearm fractures in older children. J Pediatr Orthop. 2008;28(4):403-9.
20. Fernandez FF, Egenolf M, Carsten C, Holz F, Schneider S, Wentzensen A. Unstable diaphyseal fractures of both bones of the forearm in children: plate fixation versus intramedullary nailing. Injury. 2005;36(10):1210-16.
21. Zheng W, Tao Z, Chen C, Zhang C, Zhang H, Feng Z, et al. Comparison of three surgical fixation methods for dual-bone forearm fractures in older children: A retrospective cohort study. Int J Surg. 2018;51:10-6.
22. Freese KP, Faulk LW, Palmer C, Baschal RM, Sibbel SE. A comparison of fixation methods in adolescent patients with diaphyseal forearm fractures. Injury. 2018;49(11):2053-7.
23. Shah AS, Lesniak BP, Wolter TD, Caird MS, Farley FA, Vander Have KL. Stabilization of adolescent both-bone forearm fractures: a comparison of intramedullary nailing versus open reduction and internal fixation. J Orthop Trauma. 2010;24(7):440-7.
24. Kose O, Deniz G, Yanik S, Gungor M, Islam NC. Open intramedullary Kirschner wire versus screw and plate fixation for unstable forearm fractures in children. J Orthop Surg (Hong Kong). 2008;16(2):165-9.

How to cite this article:
Duran Topak, Fatih Doğar, Muhammet Yıldız, Ökkeş Bilal, Özhan Şakı, Ersin Ekici. Comparison of two different surgical treatments of forearm double diaphysis fractures in adolescents. Ann Clin Anal Med 2020;11(5):457-461